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COMPARISON OF PAPER MOLDING AND SLURRY PROCESSES FOR MANUFACTURE OF 60-MM M204 AND 81-MM M205 PROPELLING CHARGE CONTAINERS

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20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*:

A ballistic test program was conducted and the results were statistically evaluated to compare nitrocellulose mortar increment containers made by both the paper molding process and the slurry process. These containers were for the M204 propelling charges for the 60-mm mortars and for the M205 propelling charges for the 81-mm mortars.

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INTRODUCTION

A new two-step, hot forming, progressive molding process was developed for the 60-mm M204 and 81-mm M205 propelling charge increment containers. The process which used nitrocellulose paper was manufactured in accordance with specification MIL-P-70475 and eliminated the use of organic solvent.[1] A total of 4,000 60-mm M204 and 2,650 81-mm M205 increment container assemblies were manufactured and met the contract requirements (ref 1). The present container assemblies are manufactured by a slurry process.

A test program was developed to compare paper molded 60-mm M204 and 81-mm M205 propelling charge increment containers manufactured by INNOVA, Inc. with increment container assemblies made by the ARMTEC slurry process with respect to ballistics.

The ballistic test plan[2] was designed in accordance with specification MIL-C-48868 for the M204 propelling charge and specification MIL-C-48882 for the M205 propelling charge.

The test program used samples from the INNOVA paper process and the ARMTEC slurry process and included such tests as:

1. Hot, +145°F; ambient, +70°F; cold, -50°F
2. Residue
3. Puddle at +70°F
4. 10-day humidity
5. Transportation rough handling at +145°F and -40°F

DISCUSSION

The ballistic tests were carried out at Camp Edward, Massachusetts. The test program specified the number of increment containers made by the paper and slurry processes and the number of rounds to be loaded for the residue, puddle, and temperature extremes tests. Velocities and pressures were obtained at +145°F, +70°F, and -40°F; also, at +70°F for the puddle test.

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[1] The old paper process used organic solvent in the preform operation of the process.

[2] Test Program Requests LCA-G-2849 and LCA-G-2850.

STATISTICAL EVALUATION

It was decided to test the hypothesis that if two populations (velocities of containers made by the slurry process and by the paper process) have normal distributions with the same means and the same variances, then the statistics have a T-distribution (ref 3, page 117). This hypothesis was tested for the M205 increment container at charges 2 through 4 at temperatures of -40, +70, and +145°F. The hypothesis was accepted since the mean velocities and variances of the paper containers are the same as the mean velocities of the slurry containers; for example, charges 2 through 4 at temperature +70°F.

Mean velocities

Charges	Paper (ft/sec)	Slurry (ft/sec)
2	605.0	602.5
3	754.3	752.0
4	.879.9	883.2

Charges 2 through 4 at -40 and +145°F are described in table 1. It can be concluded that the mean velocities using the paper containers were the same as the mean velocities using the slurry containers for the charges 2 through 4. The same populations (from table 1) show that the mean velocities were the same for the charges 2 through 4 and the puddle test. It was also noted that there was no significant difference in the pressure.

The same hypothesis was also tested for the M204 container but the hypothesis was not accepted since the means were different; for example, charges 2 through 4 at +70°F.

Mean velocities

Charges	Paper (ft/sec)	Slurry (ft/sec)
2	543.0	531.0
3	667.4	656.1
4	764.0	756.7

This difference may be due to the ignition cartridge used (Lot MA-80E002-003) which was accepted on waiver because of a high standard deviation. The

ignition cartridge lot used during the ballistic testing had a history of generating high standard deviations. In the past, the substitution of a different ignition cartridge lot has been shown to bring the standard deviations and means down to acceptable levels. It is felt that if a new lot of ignition cartridges is used, the mean velocities and standard deviations will be the same for both the M204 paper and slurry containers. This change would make the paper containers equivalent to the slurry containers.

The raw data (velocity in ft/sec) is plotted in figures 1 and 2. The data are for the velocity of charges 2, 3, and 4 at temperatures -40, +70, and +145°F; and charge 4 for the puddle test. A graphical comparison of the data is made by plotting all the individual data points (represented by X's) and the mean of each set of data points represented by lines. The graph is an ideal method for visualizing differences in the data. The data for container assemblies made by the paper process appear to have about the same dispersion as the data of the container assemblies made by the slurry process for both the 60-mm and the 81-mm. The graph is another method for showing that the container assemblies made by the paper process are similar to the container assemblies made by the slurry process.

The 30-second puddle test did not significantly affect the velocity of the increment containers made by either process.

Results of the residue test--conducted in accordance with MIL-C-4882 and MIL-C-48868--are contained in tables 2 and 3. Included in the tables are the number of flaming debris and scorchers for 25 rounds of each charge. There were no hangups; no rounds exhibited secondary flame at any charge; and no flaming debris was observed at charge 4. The tube was dry-swabbed after each 25-round series and there was no evidence of residue. The tube was turned over after each 25-round series and there was no evidence of residue.

The velocity results of rounds tested after transportation rough handling, listed in tables 4 and 5, were not significantly affected by the hot and cold cycling of the test. No propelling charges were broken and all rounds functioned as required. The transportation rough handling test also shows that the paper-molded increment containers are ballistically equivalent to the slurry-processed increment containers.

CONCLUSIONS

1. The results of the 10-day temperature/humidity tests (table 6) showed that the paper-molded increment containers and the slurry-molded containers were not significantly affected by the tests (30-sec puddle test, residue test, transportation rough handling test, 10-day humidity test, and the ballistic temperature extremes test).

2. The paper-molded containers and the slurry-molded containers are ballistically equivalent.

3. The paper-molded process can be used for the M204 and M205 container assemblies.

RECOMMENDATIONS

It is recommended that the drawings and specifications be issued for the 60-mm M204 and 81-mm M205 propelling charge increment containers to include the paper process as a manufacturing option in addition to the slurry process.

The paper process can be used as an alternate process for the manufacture of the 60-mm M204 and 81-mm M205 propelling charge increment containers.

REFERENCES

1. Michael D. Saxon, "Prototype Production Tooling for Paper Molding 60mm, M204 and 81mm, M205 Propellant Charge Increment Containers," Contractor Report, INNOVA, Inc., 5170 126th Avenue North, Clearwater, FL 33520, February 22, 1984.

2. Wilfred Dixon and Frank J. Massey, Jr., Introduction to Statistical Analysis, third edition, McGraw-Hill Book Co., New York, 1969.

Table 1. Assessment of ballistic tests on 60-mm M204 and 81-mm M205 propelling charge increment containers

Charge	-40°F		+70°F		+145°F		Puddle test	
	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ
60-mm M204 Increment Containers								
Paper Molded								
1								
2	518.1 H_1	11.36 H_o	543.0 H_1	6.35 H_o	554.7 H_1	6.80 H_o		
3	621.7 H_1	12.34 H_o	667.4 H_1	9.96 H_o	662.6 H_o	9.88 H_o		
4	725.6 H_1	8.17 H_o	764.0 H_1	11.75 H_o	779.5 H_1	13.12 H_o	730.0 H_o	19.48 H_o
Slurry								
1								
2	506.1	7.99	531.0	6.40	545.1	7.00		
3	595.8	7.92	656.1	10.52	656.9	14.77		
4	698.4	15.88	756.7	13.08	776.8	11.99	732.3	11.52
81-mm M205 Increment Containers								
Paper Molded								
1					449.2 H_o	4.80 H_1		
2	568.2 H_o	5.53 H_o	605.0 H_o	3.71 H_o	625.4 H_o	1.48 H_1		
3	694.2 H_o	8.03 H_o	754.3 H_o	3.69 H_o	773.9 H_o	2.29 H_1		
4	827.0 H_1	8.23 H_o	879.9 H_o	5.41 H_o	899.2 H_o	4.90 H_1	878.0 H_o	2.55 H_1
Slurry								
1					451.9	2.63		
2	564.9	5.53	602.5	3.44	623.9	2.46		
3	695.4	10.13	752.0	3.60	771.1	2.83		
4	818.3	7.26	883.2	4.18	903.6	3.55	871.2	8.52

NOTES:

Reference TPR -2849 and TPR-2850

$\bar{x}$ = mean velocity in feet per second

σ = standard deviation of the velocity in feet per second

H_1 = different populations

H_o = same populations

Table 2. Results of residue test of M205 propelling charge

Charge	Type of container	Flaming debris	Scorchers	Time in min/sec required to fire 25 rds
1	paper	1	6	5 min.
1	slurry	3	4	5 min. 30 sec.
2	paper	1	0	2 min. 40 sec.
2	slurry	0	2	2 min. 30 sec.
3	paper	0	0	2 min.
1	paper	1	6	1 min. 10 sec.
4	paper	0	0	3 min. 10 sec.
4	slurry	0	0	2 min. 35 sec.
1	paper	0	2	1 min. 50 sec .
2	paper	0	1	1 min. 55 sec.

NOTES:

a. Conducted in accordance with para. 4.5.5. of MIL-C-48882.

b. Reference TPR-2850

Table 3. Results of residue test of M204 propelling charge

Charge	Type of container	Flaming debris	Scorchers	Time in min/sec required to fire 25 rds
1	paper	3	0	3 min.
1	slurry	0	5	2 min. 30 sec.
2	paper	1	1	1 min. 10 sec.
2	slurry	2	0	1 min. 30 sec.
3	paper	2	0	1 min. 30 sec.
1	paper	0	0	1 min. 20 sec.
4	paper	0	0	2 min.
4	slurry	0	1	2 min.
1	paper	0	5	1 min. 10 sec.
2	paper	0	3	2 min.*

* Tenth round did not fire (misfire) because of a bad ignition cartridge. A new ignition cartridge was added and the round fired.

NOTES:

a. Conducted in accordance with para. 4.5.5. of MIL-C-48868

b. Reference TPR-2849

Table 4. Results of transportation rough handling test of M204 propelling charge

Paper Velocity (ft/sec)	Slurry Velocity (ft/sec)
Temperature (+145°F)	
787	772
794	779
797	781
792	766
795	795
795	781
804	764
791	784
$\bar{x}$ 794	$\bar{x}$ 778
σ 4.96	σ 10.14
Temperature (-40°F)	
785	772
789	775
776	velocity lost
795	782
793	778
779	768
792	773
784	772
$\bar{x}$ 787	$\bar{x}$ 774
σ 6.82	σ 4.37

NOTES:

a. Conducted in accordance with para. 4.5.7 of MIL-C-48868

b. No propelling charges were broken open; all rounds functioned (32 rounds were fired).

Table 5. Results of transportation rough handling test of M205 propelling charge

Paper Velocity (ft/sec)		Slurry Velocity (ft/sec)	
	Temperature (+145°F)		
	888		881
	887		882
	892		890
$\bar{x}$	889	$\bar{x}$	884
σ	2.65	σ	4.93
	Temperature (-40°F)		
	888		883
	887		886
	882		878
$\bar{x}$	886	$\bar{x}$	882
σ	3.32	σ	4.04

NOTES:

a. Conducted in accordance with para 4.5.7 of MIL-C-48882.

b. No propelling charges were broken open and all rounds functioned (12 rounds were fired).

Table 6. 10-day humidity test of 60-mm M204 and 81-mm M205 increment containers at charge 4

60-mm M204

	Velocity (ft/sec)	
	Paper	Slurry
$\bar{x}$	756	737
σ	6.35	11.20

81-mm M205

	Velocity (ft/sec)	
	Paper	Slurry
$\bar{x}$	890	880
σ	2.42	2.23

NOTES:

$\bar{x}$ = mean velocities

σ = standard deviations

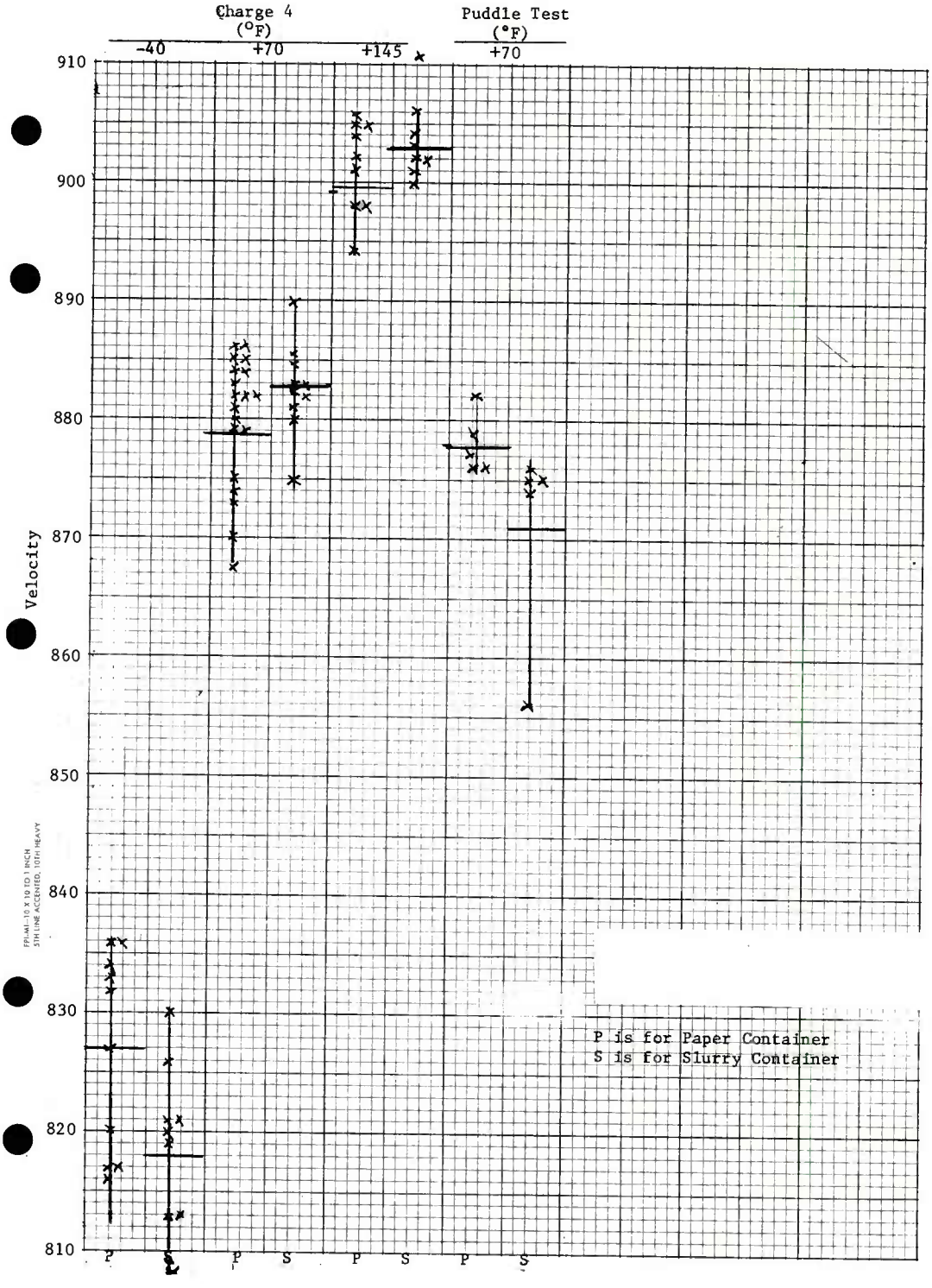

Figure 1. Data points of velocity (ft/sec) for charge 4 of M205 container of the 81-mm propelling charge

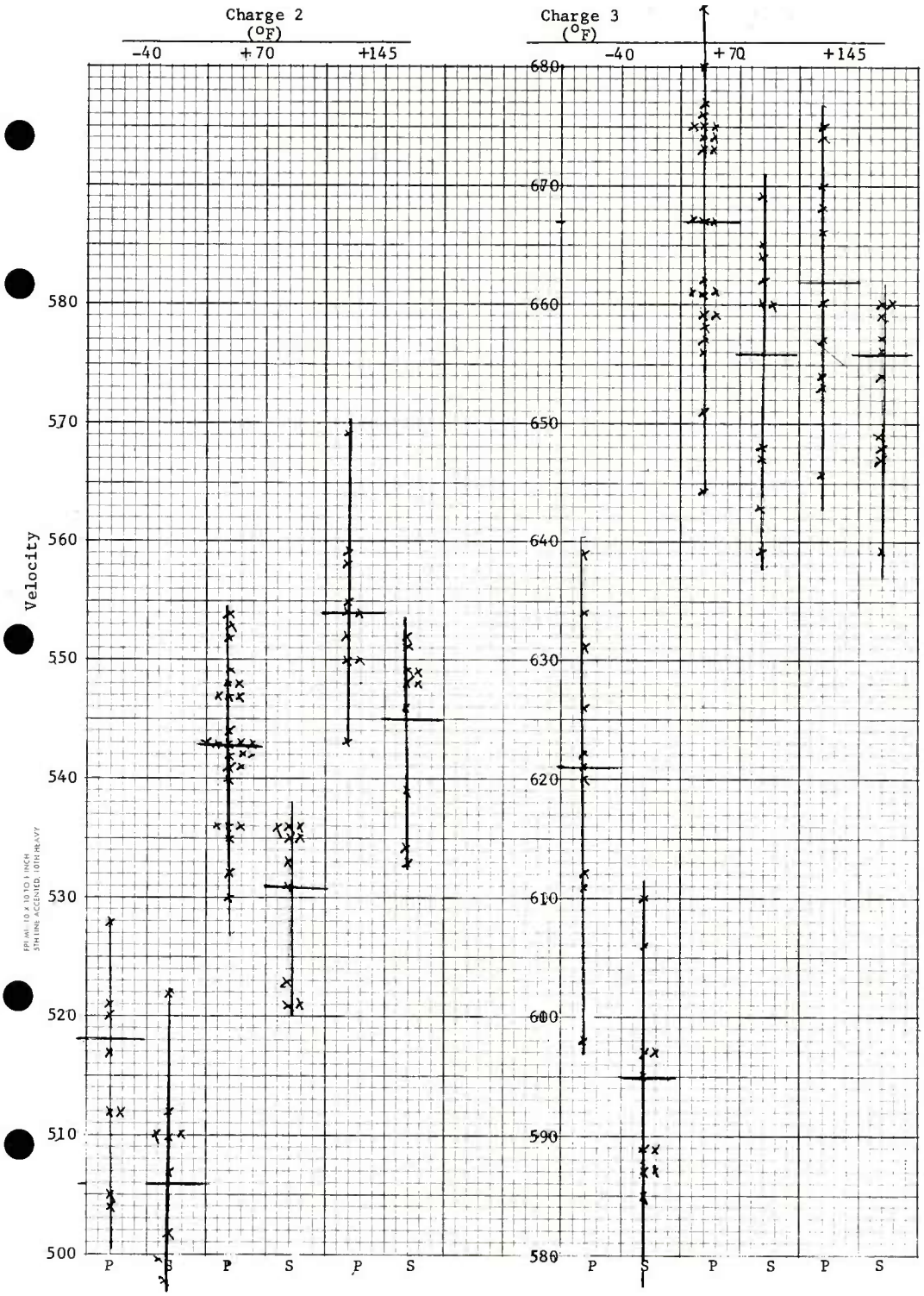

Figure 1. (cont)

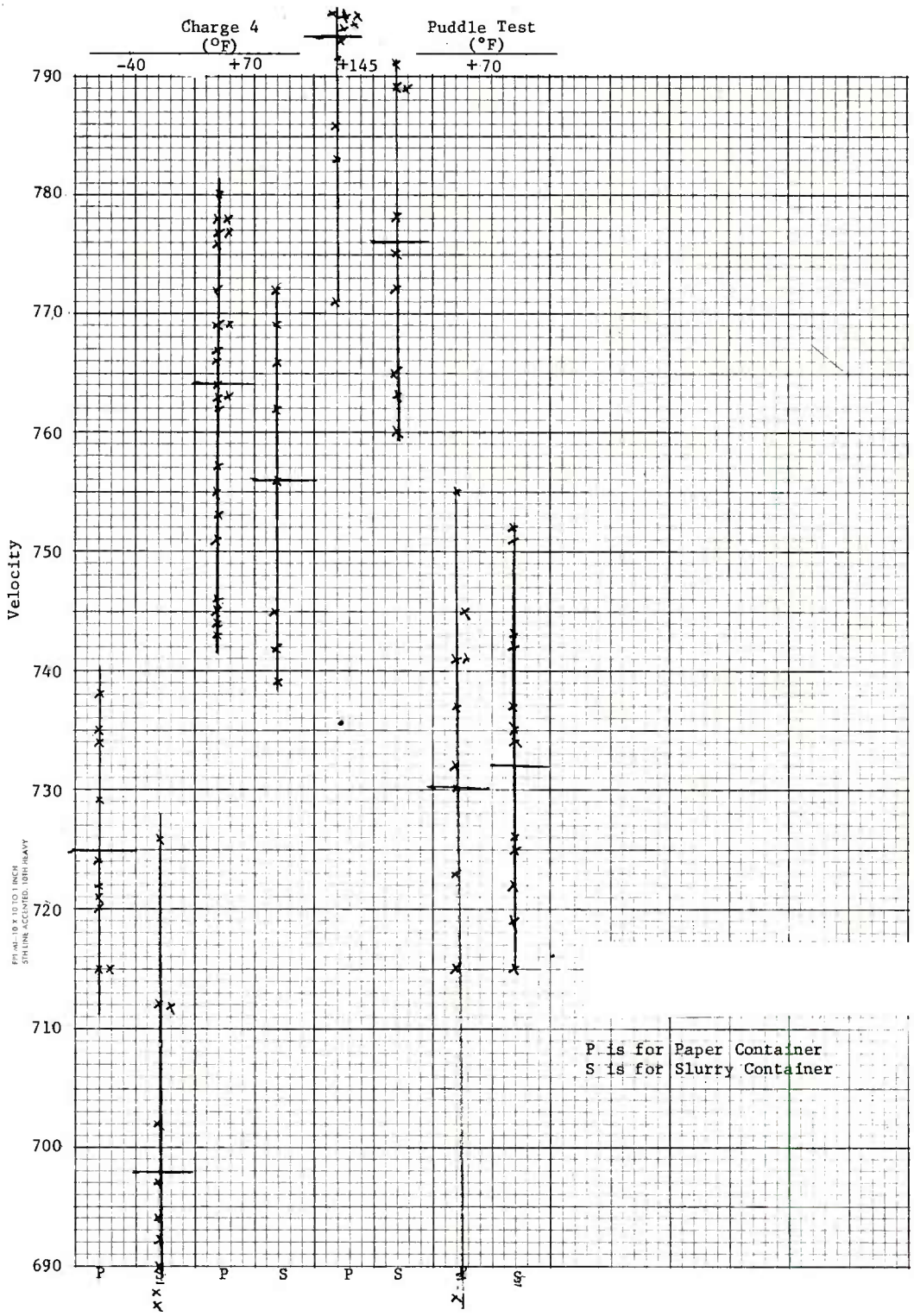

Figure 2. Data points of velocity (ft/sec) for M204 container of the 60-mm propelling charge

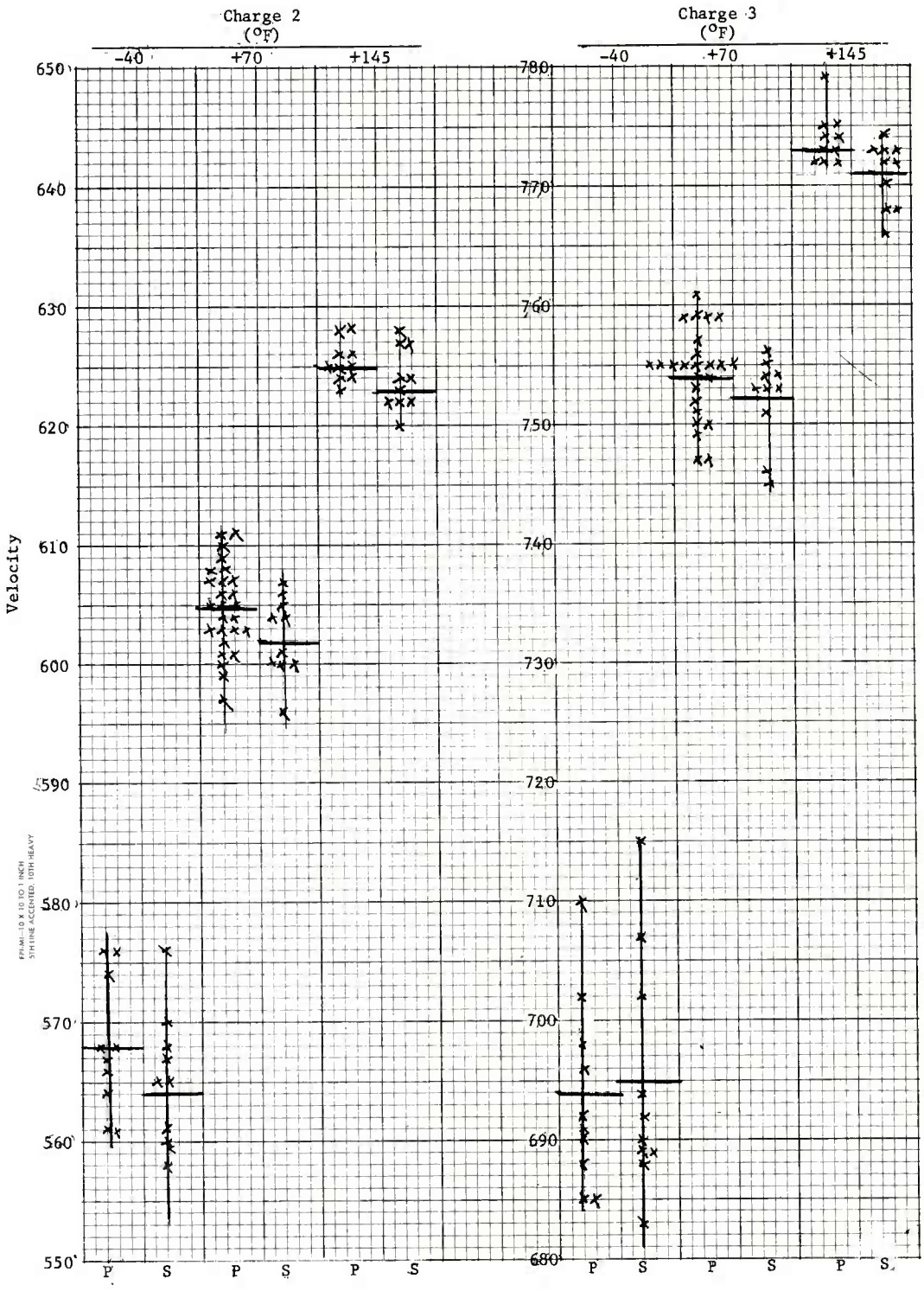

Figure 2. (cont)

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